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(21)Application number : 2001-060557 (71)Applicant : NISSAN MOTOR CO LTD

(22)Date of filing : 05.03.2001 (72)Inventor : SUZUKI KEISUKE

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(54) CONTROL DEVICE FOR FUEL CELL AND ELECTRIC CAR

(57)Abstract:

PROBLEM TO BE SOLVED: To detect with accuracy water choking irrespective of a change in power generation characteristics due to lapse of time or an operation state.

SOLUTION: An operation state detecting means 101 detects at least pressure of fuel gas and oxidant gas at entrance or exit of a fuel cell, and a cell voltage detecting means 102 detects actual voltage of a unit cell or a cell group consisting of a plurality of unit cells. A standard voltage calculation means 103 calculates a standard voltage of the cell group based on the outputs from the operation state detecting means 101 and the cell voltage detecting means 102, and a water choking state judgment means 104 judges on a water choking state based on outputs from the cell voltage detection means 102 and the standard voltage calculating means 103, while a purge control means 105 makes a purge control based on outputs of judgment results of the water choking state judgment means 104.

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CLAIMS

[Claim(s)]

[Claim 1] In the control unit of the fuel cell equipped with the cel stack which carried out the laminating of two or more cels An operational status detection means to detect the pressure of the fuel gas in the inlet port or outlet of said cel stack, and oxidant gas at least, A reference voltage operation means to calculate the reference voltage based on the theoretical electrical-potential-difference value of a cel group which consists of a single cel or two or more single cels based on the output of this operational status detection means, A cel electrical-potential-difference detection means to detect the actual voltage of the cel group of a fuel cell, and a **** ball condition judging means to judge the **** ball condition of a cel based on the output of this cel electrical-potential-difference detection means, and the output of said reference voltage operation means, The control unit of the fuel cell characterized by having the purge control means which performs water purge control for discharging the water which collected on the cel based on the judgment result of this **** ball condition judging means.

[Claim 2] Said **** ball condition judging means is the control unit of the fuel cell according to claim 1 characterized by calculating the parameter showing the

magnitude of the change from the theoretical value of a cel electrical potential difference, and judging a **** ball condition with the magnitude of this parameter from the theoretical electrical-potential-difference value of the cel group calculated with said reference voltage operation means, and the electrical-potential-difference value of the cel group detected with the cel electrical-potential-difference detection means.

[Claim 3] Said reference voltage operation means is the control unit of the fuel cell according to claim 1 or 2 characterized by amending and calculating a theoretical electrical-potential-difference value with the study value based on the cel electrical-potential-difference detection value of the predetermined period immediately after performing water purge control in case the reference voltage level of a cel group is calculated.

[Claim 4] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 1 to which temperature is characterized by having a temperature detection means to detect the temperature distribution of a cel group, and judging a **** ball based on the cel electrical-potential-difference detection value of a cel lower than a predetermined value thru/or claim 3.

[Claim 5] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 2 to which temperature is characterized by having a temperature detection means to detect the temperature distribution of a cel

group, applying bigger weight to the operation value of said parameter based on the cel electrical-potential-difference detection value of a low cel, and judging a **** ball thru/or claim 4.

[Claim 6] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 1 characterized by judging a **** ball based on the predetermined cel electrical-potential-difference detection value of the cooling water entrance side of a fuel cell stack thru/or claim 5.

[Claim 7] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 2 characterized by applying bigger weight to the operation value of said parameter based on the cel electrical-potential-difference detection value near the cooling water entrance side of a fuel cell stack, and judging a **** ball to it thru/or claim 5.

[Claim 8] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 1 characterized by judging a **** ball based on the predetermined cel electrical-potential-difference detection value of a side with high gas pressure among the cels of a fuel cell stack thru/or claim 5.

[Claim 9] Said **** ball condition judging means is the control unit of a fuel cell given in any 1 term of claim 2 characterized by applying bigger weight to the operation value of said parameter based on the cel electrical-potential-difference detection value near a side with high gas pressure, and judging a **** ball among

the cels of a fuel cell stack thru/or claim 7.

[Claim 10] the square of a difference with the actual voltage value of the cel group which detected said parameter with the reference voltage level of a cel group, and the cel electrical-potential-difference detection means -- the control unit of a fuel cell given in any 1 term of claim 2 characterized by being the average thru/or claim 9.

[Claim 11] The electric vehicle characterized by having the control unit of the fuel cell of claim 1 thru/or claim 10 given in any 1 term in order to control a fuel cell and this fuel cell.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the electric vehicle in which the control unit of a fuel cell and fuel cell which detect the **** ball of a fuel cell stack and control a water purge were carried.

[0002]

[Description of the Prior Art] In a fuel cell, the generation water produced as a

result of the reaction of oxygen [hydrogen and] and the liquid hydrogen produced when the steam contained in fuel gas and oxidant gas condenses may pile up in a cel. In this case, in the cel in which water piled up, the flow of gas will be checked, and sufficient hydrogen and oxygen cannot be supplied, but a cel electrical potential difference will fall, and, as a result, an output will decline. Therefore, when stagnation (**** ball of a cel) of such water arises, it is necessary to do promptly the activity of "a purge" which discharges the water which was made to increase a quantity of gas flow and collected, to scavenge the inside of each cel of a fuel cell, and to recover an output. [0003] There are JP,7-022047,A and JP,9-245826,A as a technique which detects the **** ball of the cel of the conventional fuel cell stack, and controls a water purge. an anode [as opposed to / the former technique prepares a reference electrode in a single cel, detect the single electrode potential of an anode and a cathode using this reference electrode, and / a change of load], and the pattern of a cathode bipolar potential change -- an anode and a cathode -- it presumes whether the **** ball is produced on the which pole, and while making the flow rate of the reagin of the pole which has produced the **** ball increase, a **** ball is canceled by stopping humidification [0004] Moreover, in the case of the various service conditions of a fuel cell, the latter technique divides the pattern of aging of the electrical potential difference

of a cell block which consists of a single cel or two or more single cels, and is beforehand stored in storage. The pattern of aging of every single cel and the electrical potential difference for every cell block is measured. The pattern of aging of the obtained electrical potential difference is compared with the pattern stored in storage, a service condition is judged, and the amount of humidification, a quantity of gas flow, etc. are controlled according to which judgment result with insufficient **** ball, film desiccation, and supply of oxidant gas.

[0005]

[Problem(s) to be Solved by the Invention] However, a technique given in JP,7-022047,A Since it is the configuration of preparing a reference electrode in one or more cels, and presuming a **** ball from the anode of a cel to a reference electrode, and the single electrode potential of a cathode, There was a trouble that distinction of whether to be what changed with **** balls whether change of single electrode potential when the operational status of a fuel cell changes was that from which the electrical potential difference in which an output is possible changed theoretically [each cel] was difficult, and could not detect a **** ball with a sufficient precision by various operational status.

[0006] Moreover, a technique given in JP,9-245826,A Since it is the configuration of judging a service condition as compared with the pattern which the pattern of aging of every single cel and the electrical potential difference for

every cell block was detected [pattern], and stored the detection value in storage beforehand, Since the property change by the secular change and aging of a property with a **** ball etc. were not able to be separated when the property of a primary fuel cell has deteriorated according to secular change by long time amount, there was a trouble that the judgment precision of service conditions, such as a **** ball, fell.

[0007] It is offering the control unit of the fuel cell which the purpose of this invention cannot require for operational status, but can detect the **** ball of a fuel cell with a sufficient precision in view of the above trouble.

[0008] Moreover, even if the purpose of this invention has change of the generation-of-electrical-energy property of the fuel cell by secular change, it is offering the control unit of the fuel cell which can detect a **** ball with a sufficient precision.

[0009] Furthermore, the purpose of this invention is offering the electric vehicle which detected the **** ball of a fuel cell with a sufficient precision, and raised fuel consumption and operability in the electric vehicle in which the fuel cell was carried.

[0010]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, to claim 1 publication invention In the control unit of the fuel cell equipped with

the cel stack which carried out the laminating of two or more cels An operational status detection means to detect the pressure of the fuel gas in the inlet port or outlet of said cel stack, and oxidant gas at least, A reference voltage operation means to calculate the reference voltage based on the theoretical electrical-potential-difference value of a cel group which consists of a single cel or two or more single cels based on the output of this operational status detection means, A cel electrical-potential-difference detection means to detect the actual voltage of the cel group of a fuel cell, and a **** ball condition judging means to judge the **** ball condition of a cel based on the output of this cel electrical-potential-difference detection means, and the output of said reference voltage operation means, Let it be a summary to have had the purge control means which performs water purge control for discharging the water which collected on the cel based on the judgment result of this **** ball condition judging means.

[0011] In order to attain the above-mentioned purpose, to claim 2 publication invention In the control unit of a fuel cell according to claim 1 said **** ball condition judging means Let it be a summary to calculate the parameter showing the magnitude of the change from the theoretical value of a cel electrical potential difference, and to judge a **** ball condition with the magnitude of this parameter from the theoretical electrical-potential-difference value of the cel

group calculated with said reference voltage operation means, and the electrical-potential-difference value of the cel group detected with the cel electrical-potential-difference detection means.

[0012] In order to attain the above-mentioned purpose, as for invention, in the control unit of a fuel cell according to claim 1 or 2, said reference voltage operation means makes it a summary to amend and calculate a theoretical electrical-potential-difference value with the study value based on the cel electrical-potential-difference detection value of the predetermined period immediately after performing water purge control at claim 3 publication, in case the reference voltage level of a cel group is calculated.

[0013] In order to attain the above-mentioned purpose, invention equips claim 4 publication with a temperature detection means to detect the temperature distribution of a cel group, in the control unit of a fuel cell given in any 1 term of claim 1 thru/or claim 3, and said **** ball condition judging means makes it a summary for temperature to judge a **** ball based on the cel electrical-potential-difference detection value of a cel lower than a predetermined value.

[0014] In order to attain the above-mentioned purpose, invention equips claim 5 publication with a temperature detection means to detect the temperature distribution of a cel group, in the control unit of a fuel cell given in any 1 term of

claim 2 thru/or claim 4, and said **** ball condition judging means makes it a summary to apply bigger weight to the operation value of said parameter based on the cel electrical-potential-difference detection value of a cel with low temperature, and to judge a **** ball.

[0015] In order to attain the above-mentioned purpose, invention is set at claim 6 publication to the control unit of a fuel cell given in any 1 term of claim 1 thru/or claim 5, and said **** ball condition judging means makes it a summary to judge a **** ball based on the predetermined cel electrical-potential-difference detection value of the cooling water entrance side of a fuel cell stack.

[0016] In order to attain the above-mentioned purpose, let it be a summary for invention to apply bigger weight to claim 7 publication at the operation value of said parameter based on a cel electrical-potential-difference detection value with said **** ball condition judging means near the cooling water entrance side of a fuel cell stack in the control unit of a fuel cell given in any 1 term of claim 2 thru/or claim 5, and to judge a **** ball.

[0017] In order to attain the above-mentioned purpose, invention makes it a summary for said **** ball condition judging means to judge a **** ball based on the predetermined cel electrical-potential-difference detection value of a side with high gas pressure in the control unit of a fuel cell given in any 1 term of claim 1 thru/or claim 5 among the cels of a fuel cell stack at claim 8 publication.

[0018] In order to attain the above-mentioned purpose, let it be a summary for invention to apply bigger weight to the operation value of said parameter based on [among the cels of a fuel cell stack] the cel electrical-potential-difference detection value near a side with high gas pressure in said **** ball condition judging means in the control unit of a fuel cell given in any 1 term of claim 2 thru/or claim 7, and to judge a **** ball at claim 9 publication.

[0019] the square of a difference with the actual voltage value of the cel group to which invention detected said parameter in the control unit of a fuel cell given in any 1 term of claim 2 thru/or claim 9 with the reference voltage level of a cel group, and the cel electrical-potential-difference detection means to the claim 10 publication in order to attain the above-mentioned purpose -- let it be a summary to be the average.

[0020] In order to attain the above-mentioned purpose, in order that invention may control a fuel cell and this fuel cell at claim 11 publication, it is the electric vehicle which makes it a summary to have had the control unit of the fuel cell of claim 1 thru/or claim 10 given in any 1 term.

[0021]

[Effect of the Invention] In the control unit of the fuel cell which was equipped with the cel stack which carried out the laminating of two or more cels according to invention of claim 1 An operational status detection means to detect the

pressure of the fuel gas in the inlet port or outlet of said cel stack, and oxidant gas at least, A reference voltage operation means to calculate the reference voltage based on the theoretical electrical-potential-difference value of a cel group which consists of a single cel or two or more single cels based on the output of this operational status detection means, A cel electrical-potential-difference detection means to detect the actual voltage of the cel group of a fuel cell, and a **** ball condition judging means to judge the **** ball condition of a cel based on the output of this cel electrical-potential-difference detection means, and the output of said reference voltage operation means, By having had the purge control means which performs water purge control for discharging the water which collected on the cel based on the judgment result of this **** ball condition judging means Even if operational status changes and a fuel cell property changes with secular change again, it is effective in the **** ball of a cel being detectable with a sufficient precision from the reference voltage according to operational status, and an actual cel electrical potential difference.

[0022] According to invention of claim 2, to the effect of the invention of claim 1 in addition, said **** ball condition judging means From the theoretical electrical-potential-difference value of the cel group calculated with said reference voltage operation means, and the electrical-potential-difference value

of the cel group detected with the cel electrical-potential-difference detection means Since the parameter showing the magnitude of the change from the theoretical value of a cel electrical potential difference is calculated and the **** ball condition was judged with the magnitude of this parameter, it is effective in the ability to judge a **** ball correctly with a parameter further. [0023] According to invention of claim 3, to the effect of the invention of claim 1 or claim 2 in addition, said reference voltage operation means Since a theoretical electrical-potential-difference value is amended and it was made to calculate with the study value based on the cel electrical-potential-difference detection value of the predetermined period immediately after performing water purge control when calculating the reference voltage level of a cel group Even when the electrical-potential-difference value of a fuel cell has shifted from the theoretical electrical-potential-difference value according to secular change, it is effective in a **** ball being detectable with a sufficient precision. [0024] According to invention of claim 4, in addition to the effect of the invention of claim 1 thru/or claim 3, it has a temperature detection means to detect the temperature distribution of a cel group. Said **** ball condition judging means Since temperature judged the **** ball based on the cel electrical-potential-difference detection value of a cel lower than a predetermined value A **** ball can be judged based on the cel

electrical-potential-difference detection value of only the cel of the low-temperature section on which there are comparatively many amounts of condensation of water, and water tends to collect, and the detection period of a cel electrical potential difference can be made into a high speed, consequently it is effective in a **** ball being detectable with a sufficient precision. [0025] According to invention of claim 5, in addition to the effect of the invention of claim 2 thru/or claim 4, it has a temperature detection means to detect the temperature distribution of a cel group, and since bigger weight is applied and the **** ball was judged, said **** ball condition judging means has the effectiveness that a **** ball can be detected with still more sufficient sensibility in the operation value of said parameter based on the cel electrical-potential-difference detection value of a cel with low temperature. [0026] According to invention of claim 6, to the effect of the invention of claim 1 thru/or claim 5 in addition, said **** ball condition judging means Since the **** ball was judged based on the predetermined cel electrical-potential-difference detection value of the cooling water entrance side of a fuel cell stack The amount of condensation of water can make a high speed comparatively the detection period of the cel electrical potential difference of the cel of the cooling water entrance side of the fuel cell stack on which water tends to collect mostly, consequently it is effective in a **** ball being detectable with a sufficient

precision.

[0027] According to invention of claim 7, to the effect of the invention of claim 2 thru/or claim 5 in addition, said **** ball condition judging means Since bigger weight is applied to the operation value of said parameter based on the cel electrical-potential-difference detection value near the cooling water entrance side of a fuel cell stack and the **** ball was judged to it Big weight can be applied with the parameter operation value based on the cel electrical-potential-difference detection value near the cooling water entrance side of the fuel cell stack on which there are comparatively many amounts of condensation of water, and water tends to collect, and it is effective in a **** ball being detectable with sufficient sensibility.

[0028] According to invention of claim 8, to the effect of the invention of claim 1 thru/or claim 5 in addition, said **** ball condition judging means Since the **** ball was judged based on the predetermined cel electrical-potential-difference detection value of a side with high gas pressure among the cels of a fuel cell stack A saturated steam flow rate can judge a **** ball now only based on the cel electrical-potential-difference detection value of a cel with the high gas pressure on which water tends [comparatively] to collect low. The detection period of the cel electrical potential difference of the cel on which water tends to collect can be made into a high speed, consequently it is effective in a **** ball being detectable

with a sufficient precision.

[0029] According to invention of claim 9, to the effect of the invention of claim 2 thru/or claim 7 in addition, said **** ball condition judging means Since bigger weight is applied to the operation value of said parameter based on the cel electrical-potential-difference detection value near a side with high gas pressure and the **** ball was judged to it among the cels of a fuel cell stack Bigger weight can be applied to the parameter operation value based on the cel electrical-potential-difference detection value of a cel with the high gas pressure on which a saturated steam flow rate is low and water tends [comparatively] to collect, a **** ball can be judged now to it, and the effectiveness that a **** ball is detectable with sufficient sensibility is in it.

[0030] according to invention of claim 10 -- the effect of the invention of claim 2 thru/or claim 9 -- in addition, the square of a difference with the actual voltage value of the cel group which detected said parameter with the reference voltage level of a cel group, and the cel electrical-potential-difference detection means -- since it considered as the average, it is effective in a **** ball being detectable with a sufficient precision by the easy operation.

[0031] According to invention of claim 11, it is effective in the ability to detect the **** ball of a cel with a sufficient precision, and raise the fuel consumption and operability of an electric vehicle, even if operational status changes by having

had the control unit of the fuel cell of claim 1 thru/or claim 10 given in any 1 term and a fuel cell property changes with secular change again in order to control a fuel cell and this fuel cell.

[0032]

[Embodiment of the Invention] Next, this invention is explained to a detail with reference to a drawing. The fundamental concept of this invention is explained before explanation of an operation gestalt. As a factor to which the electrical potential difference of the cel of a fuel cell falls, although there are also a fall of the oxygen tension in an air pole and a fall of the hydrogen partial pressure in a hydrogen pole, the inclination to appear as a specific cel or the sag of a cel group, i.e., dispersion of a cel electrical potential difference, has the influence with the **** ball of a cel to the fall of these partial pressures appearing as sag of the whole cel. Therefore, if the magnitude of dispersion in the actual voltage from the reference voltage of a cel group when the **** ball has not arisen is calculated, while being able to detect a **** ball correctly, consequently controlling an unnecessary water purge, when a water purge is required, a water purge can be performed certainly.

[0033] Moreover, although the reference voltage of a cel group may have shifted from the theoretical electrical potential difference according to secular change, if the gap by secular change is learned from the actual voltage value of the cel

group in the condition that there is no **** ball immediately after performing water purge control and you make it reflected in the operation of reference voltage, irrespective of secular change, it can detect a **** ball with a sufficient precision, and can perform water purge control certainly.

[0034] Drawing 1 is the block diagram showing the basic configuration of the control unit of the fuel cell concerning this invention. An operational status detection means 101 by which the control unit of a fuel cell detects the pressure of the fuel gas in a fuel cell inlet port or an outlet, and oxidant gas at least in this drawing, A cel electrical-potential-difference detection means 102 to detect the actual voltage of a cel group which consists of a single cel or two or more single cels, A reference voltage operation means 103 to calculate the reference voltage of a cel group based on the operational status detection means 101, the cel electrical-potential-difference detection means 102, and the output of 105 mentioned later, It has a **** ball condition judging means 104 to judge the **** ball condition of a cel based on the output of the cel electrical-potential-difference detection means 102 and the reference voltage operation means 103, and the purge control means 105 which performs purge control based on the judgment result output of the **** ball condition judging means 104.

[0035] Drawing 2 is the system configuration Fig. showing the fuel cell structure

of a system to which the control unit of the fuel cell concerning this invention is applied, and although it is not limited especially, it is a suitable fuel cell system for an electric vehicle.

[0036] As shown in drawing 2 , the fuel cell system by which this invention is applied The fuel cell stack 201 which has the fuel electrode and air pole which are not illustrated, and is generated according to the electrochemical reaction of the hydrogen which is fuel gas, and the oxygen in air (body of a fuel cell), The humidifier 202 which humidifies hydrogen and air, and the compressor 203 which compresses the air adopted from the outside and is sent to a humidifier 202, The adjustable bulb 204 which controls the flow rate of high-pressure hydrogen, and the throttle 205 which controls the pressure and flow rate of air, The purge valve 206 which exhausts hydrogen outside, and the pure water pump 207 which supplies pure water to a humidifier 202, It has the pressure sensor 208 which detects the air pressure of a fuel cell inlet port, the pressure sensor 209 which detects the hydrogen pressure force of a fuel cell inlet port, the cel electrical-potential-difference detection electrodes 211a, 211b, --, 211z, and the controller 210 which controls a fuel cell.

[0037] The correspondence relation between drawing 1 and drawing 2 is as follows. The operational status detection means 101 of drawing 1 is equivalent to the pressure sensor 209 which detects the pressure sensor 208 and the

hydrogen pressure force of detecting the air pressure of drawing 2 , and the cel electrical-potential-difference detection means 102 of drawing 1 is equivalent to the cel electrical-potential-difference detection electrodes 211a, 211b, --, 211z. The reference voltage operation means 103, the **** ball condition judging means 104, and the purge control means 105 of drawing 1 are equivalent to a controller 210.

[0038] A compressor 203 humidifies air with the pure water which compressed air and was supplied to the humidifier 202 by the pure water pump 207 with delivery and a humidifier 202, and the humidified air is sent into the fuel cell stack 201. A flow rate is controlled by the adjustable bulb 204, high-pressure hydrogen is sent to a humidifier 202, with a humidifier 202, hydrogen is humidified with the pure water supplied by the pure water pump 207 like air, and the humidified hydrogen is sent into the fuel cell stack 201. In the fuel cell stack 201, it generates electricity by making the air and hydrogen which were sent in react, and a current (power) is supplied to external systems, such as a car. The remaining air used for the reaction by the fuel cell stack 201 is discharged to atmospheric air, after pressure control is performed by the throttle 205.

[0039] Moreover, although the remaining hydrogen used for the reaction is discharged from the fuel cell stack 201, it flows back to the upstream of a humidifier 202, and is reused to a generation of electrical energy. Now, it has the

pressure sensor 208 which detects the air pressure of a fuel cell inlet port, and the pressure sensor 209 which detects the hydrogen pressure force, and these signals are read into a controller 210 with the cel electrical potential difference of the cel group of a fuel cell. The throttle 205 by the side of air and the purge valve 206 of hydrogen are opened, and water collected on the interior of a fuel cell is discharged outside, and when the situation of the **** ball of a cel is judged from the read value and it judges with the **** ball having arisen, it controls by the controller 210 so that the output of a fuel cell is recovered. [0040] Drawing 3 is the (a) reference voltage level (= theoretical electrical-potential-difference value Vest0 (i)) of each cel when setting a cel number to i, and always [(b) forward] drawing showing the situation of change of the real cel electrical potential difference Vcell at the time of (c) **** ball (i). The theoretical electrical-potential-difference value Vest0 of the cel number i of a fuel cell (i) "electrochemistry introduction" (Matsuda and the Iwakura collaboration, and Maruzen Co., Ltd.) and "new electrochemistry" (the edited by Electrochemical Society of Japan --) "Nernst's equation" of publications, such as Baifukan, "polarization (activity polarization, concentration polarization)", Based on the publication of "limiting current density" etc., it is computable with the theoretical formula showing in (1) type from oxygen tension (Bo2), a hydrogen partial pressure (Bh2), a drawing current (Ic), and stack temperature (Tfc).

[0041]

[Equation 1]

$$Vest0 = K0 - T_{fc} \cdot \left\{ K1 \cdot \ln(B_{h2}) + K2 \cdot \ln(B_{o2}) + K3 \cdot \ln(Ic) \right\} + K4 \cdot T_{fc}$$

$$+ K5 \cdot Ic + T_{fc} \cdot K1 \left\{ \ln\left(\frac{I_{h2,L} - Ic}{I_{h2,L}} \right) + \ln\left(\frac{I_{o2,L} - Ic}{I_{o2,L}} \right)^{\frac{1}{2}} \right\} \quad \cdots (1)$$

Here, the hydrogen limiting current density it is decided by K1 to K5 from Bh2 and Tfc that a constant, and Ih2 and L will be, and Io2 and L are oxygen limiting current density decided from Bo2 and Tfc.

[0042] Moreover, it can ask for partial pressures Bh2 and Bo2 from the oxygen density in the steam partial pressure decided by drawing 5 from stack temperature, the air pressure Po 2 of a stack inlet port and the hydrogen pressure force Ph2, and air. Since the pressure in each cel in a fuel cell declines gradually as it approaches an outlet side by the pressure loss of internal piping, if this pressure-loss property is investigated in advance, the theoretical electrical-potential-difference value for every cel for which it asked from the theoretical formula will become like drawing 3 (a). Here, it shall ask for the parameter which shows the magnitude of dispersion from the reference value of each cel electrical potential difference by the following (2) types.

[0043]

[Equation 2]

$$X = \frac{1}{Ncell} \sum_{i=1}^{Ncell} \left\{ Vcell(i) - Vest(i) \right\}^2 \quad \cdots (2)$$

Although it can judge that the parameter value of (2) types will become small if the actual voltage value of each cel is mostly in agreement with a reference voltage level now as shown in drawing 3 (b), and the **** ball is not produced, since there is cel [value / theoretical electrical-potential-difference] greatly shifted if detected like drawing 3 (c), the parameter value of (2) types becomes large and it can be judged that the **** ball is produced. [0044] The situation of the real cel electrical potential difference Vcell at the time of (d) **** ball (i) is always [(reference voltage level Vest (i) and c) forward] which amended (a) theoretical electrical-potential-difference value Vest0 of each cel (i), and the property gap by (b) secular change with the study value shown in drawing 4 . The theoretical electrical-potential-difference value Vest0 of each cel (i) is first calculated like the case of drawing 3 using (1) type from the stack inlet air pressure Po 2, the hydrogen pressure force Ph2, the stack temperature Tfc, the drawing current Ic, and a pressure-loss property (drawing 4 (a)). [0045] Moreover, immediately after performing a water purge, it is based on the

actual voltage value Vcell of each cel (i), and they are the following (3) types [several 3].

$$k(i, p) = \alpha \cdot k(i, p-1) + (1-\alpha) \cdot \frac{1}{N} \sum_{n=1}^{N} \frac{Vcell(i, n)}{Vest0(i)} \quad \cdots(3)$$

The correction factor to ******** secular change is learned, the study value is used, and they are the following (4) types [several 4] about a reference voltage level Vest (i).

Vest(i) =k (i, p) and Vest0 (i) -- (4)

A ******** operation is carried out. Here, it is the study value alpha after the Pth water purge of the k(i, p):cel i. : Moving-average multiplier of renewal of a study value (0< alpha<1)

N : it is the number of data once used for study.

[0046] Although the reference voltage level in each cel may shift from a theoretical electrical-potential-difference value when there are secular change, a reference voltage level like drawing 4 (b) can be calculated by amending a theoretical electrical-potential-difference value with the study value of (3) types. The parameter which shows the degree of dispersion in a cel electrical potential difference using (2) types from the reference voltage level Vest (i) calculated by (4) formulas next and the actual voltage value Vcell of each cel (i) is calculated.

Although it can judge that the parameter value of (2) types will become small if the actual voltage value of each cel is mostly in agreement with a reference voltage level as shown in drawing 4 (c), and the **** ball is not produced, since there is cel [value / theoretical electrical-potential-difference] greatly shifted if detected like drawing 4 (d), the parameter value of (2) types becomes large and it can be judged that the **** ball is produced.

[0047] Moreover, although here explained the detection based on the electrical potential difference of a single cel, even if this uses the electrical potential difference of a cel group which consists of two or more single cels, it can be detected similarly.

[0048] The [1st operation gestalt] Next, actuation of the 1st operation gestalt which showed the configuration is explained to drawing 1 and drawing 2 at a detail with reference to the flow chart of drawing 7 , drawing 8 , drawing 10 , and drawing 13 . Drawing 7 is the General flow chart which shows the whole actuation, and is performed for every (every [For example, 10[] ms]) predetermined time by the controller 210 of drawing 2 .

[0049] The air pressure Pair0 of a fuel cell stack inlet port and the hydrogen pressure force Ph20 are detected, and the current value Ic now taken out from the fuel cell is detected by S703 step (a step is hereafter abbreviated to S) 701, and S702. In S704, the reference voltage level Vest (i) of each cel (i= 1 - Ncell) is

calculated based on the detected value, and the actual voltage value Vcell of each cel (i) is detected in S705. The parameter which expresses a **** ball with S706 based on a reference voltage level and an actual voltage value is calculated, and in S707, according to the calculated parameter, water purge control is performed and it ends.

[0050] Drawing 8 shows the contents of the procedure of the reference voltage level Vest (i) operation in S704 of drawing 7 .

[0051] In S801, the air pressure Pair0 of the detected fuel cell stack inlet port and the air pressure Pair in the pressure-loss property of an air pole to each cel (i) are presumed. Here, the pressure-loss property shall investigate the property of the actual thing in the experiment in advance, and shall give it on the map on which the rate of a pressure drop can be found from a flow rate (or output) as shown in drawing 6 (a), and a cel number. In S802, the hydrogen pressure force Ph20 of the detected fuel cell stack inlet port and the hydrogen pressure force Ph2 in the pressure-loss property of a hydrogen pole to each cel (i) are presumed. The pressure-loss property of hydrogen shall be given by drawing 6 (b) like the case of air. The temperature Tfc of a fuel cell stack is detected in S803, and the steam partial pressure Bvapor is calculated from temperature and the steam partial pressure property of drawing 5 in S804. In S805, the oxygen tension Bo2 in each cel (i) is calculated from the oxygen density Ro2 in the air

pressure estimate Po 2 in each cel (i), the steam partial pressure Bvapor, and air. In S806, the hydrogen partial pressure Bh2 in each cel (i) is calculated from the hydrogen pressure force estimate Ph2 in each cel (i), and the steam partial pressure Bvapor. Based on (1) type, the theoretical electrical-potential-difference value Vest0 in each cel (i) is calculated, and by S808, to the reference voltage level Vest in each cel (i), the theoretical electrical-potential-difference value Vest0 (i) is assigned, and it ends S807.

[0052] The contents of the procedure of the **** ball parameter operation in S706 of drawing 7 are shown in drawing 10 . The reference voltage Vest of each cel calculated by S704 of drawing 7 (i) is read, and the actual voltage Vcell of each cel calculated by S705 of drawing 7 (i) is read by S1002 S1001. In S1003, using (2) types, the parameter X showing a **** ball is calculated and it ends.

[0053] The contents of the procedure of the water purge control activation in S707 of drawing 7 are shown in drawing 13 . In S1301, the value of the flag PFlag showing under purge activation is judged. When it is judged that it is not [purge / be / it] under activation by S1301 (PFlag=0), it progresses to S1302, and it judges whether Parameter X is larger than threshold Xpurge which judges a **** ball. If it is judged as a **** ball (X>Xpurge) by S1302, an air throttle is made full open by S1303, a hydrogen purge valve is made full open by S1304, and it is referred to as PFlag=1 by S1305, and by S1306, it will be referred to as

counter=0 and will end. Moreover, when it is judged by S1302 that it is not a **** ball (X<=Xpurge), it ends as it is. If it judges that it is [purge] under activation by S1301 (PFlag=1), 1 will be added to counter by S1307, and it will progress to S1308. In S1308, it is referred to as flag PFlag=0 which judges whether counter is larger than the time amount Tpurge of purge activation, usually returns the air throttle made full open by S1309 to control when large, opens a hydrogen purge valve fully by S1310, and expresses under purge activation with S1311, and ends. Moreover, when counter is not judged to be larger than the time amount Tpurge of purge activation by S1308, it ends as it is.

[0054] The [2nd operation gestalt] The 2nd operation gestalt is shown in the flow chart of drawing 7 , drawing 9 , drawing 10 , and drawing 13 . Since drawing 7 , drawing 10 , and drawing 13 are the same as that of the 1st operation gestalt, only drawing 9 is explained.

[0055] The contents of the procedure of the reference voltage (Vest (i)) operation in S704 of drawing 7 are shown in drawing 9 . Since it is the same as that of S801 to 807 of drawing 8 , S901 to S907 is omitted. In S908, the correction factor k (i, p) computed by (3) types based on the data of the predetermined time after purge control activation is read, and the value which multiplied the theoretical electrical-potential-difference value Vest0 in each cel (i) by the correction factor of each cel is assigned to S909 at a reference voltage level

Vest (i), and it ends.

[0056] The [3rd operation gestalt] The 3rd operation gestalt is shown in the flow chart of drawing 7 , drawing 8 (or drawing 9), drawing 11 , and drawing 13 . This operation gestalt is an operation gestalt when the temperature of each cel can measure or presume. Since drawing 7 , drawing 8 , and drawing 13 are the same as that of the 1st operation gestalt, only drawing 11 is explained.

[0057] The contents of the procedure of the **** ball parameter operation in S706 of drawing 7 are shown in drawing 11 . The reference voltage Vest of each cel calculated by S704 of drawing 7 (i) is read, and the actual voltage Vcell of each cel calculated by S705 of drawing 7 (i) is read by S1102 S1101. The initial value of the variable i which expresses a cel number with S1103 is set as i= 1, and the temperature Tcell of each cel (i) is detected in S1104. In S1105, weighting-factor W (i) according to cel temperature is calculated based on the table data shown in drawing 14 . Variable i is increased one time, and by S1107, it judges whether Variable i is larger than Ncell, and when not large, it returns to S1104 S1106. If only Ncell repeats this operation and weighting-factor [of a cel 1 - Cel Ncell] W (i) is calculated, the loop-formation terminating condition of S1107 will be satisfied, and it will progress to S1108. The parameter X which expresses a **** ball with S1108 to (2) types using the formula which weighting-factor W (i) joined is calculated, and it ends.

[0058] Moreover, since the temperature of each cel can be measured or presumed, when fuel cell stack temperature Tfc of S803 of drawing 8 is made into the temperature Tfc for every cel (i) and the steam partial pressure Bvapor calculated by S804 performs subsequent operations as Bvapor (i), precision can be raised more with this operation gestalt.

[0059] The [4th operation gestalt] The 4th operation gestalt is shown in the flow chart of drawing 7 , drawing 8 (or drawing 9), drawing 12 , and drawing 13 . It is an operation gestalt when the temperature of each cel can measure or presume this operation gestalt as well as the 3rd operation gestalt. Since drawing 7 , drawing 8 , and drawing 13 are the same as that of the 1st operation gestalt, only drawing 12 is explained.

[0060] The contents of the procedure of the **** ball parameter operation in S706 of drawing 7 are shown in drawing 12 . In drawing 12 , the reference voltage Vest of each cel calculated by S704 of drawing 7 (i) is read, and the actual voltage Vcell of each cel calculated by S705 of drawing 7 (i) is read by S1202 S1201. Initial value of the variable i which expresses a cel number with S1203 is set to i= 1, and the temperature Tcell of each cel (i) is detected in S1204. In S1205, it judges whether the detected temperature Tcell (i) is lower than the predetermined temperature Tdew. When the cel temperature Tcell (i) judges that it is lower than Tdew by S1205, it progresses to S1206, and 1 is

substituted for multiplier S (i) and it progresses to S1208. When the cel temperature Tcell (i) does not judge that it is lower than Tdew by S1205, it progresses to S1207, and 0 is substituted for multiplier S (i) and it progresses to S1208. Variable i is increased one time, and by S1209, it judges whether Variable i is larger than Ncell, and when not large, it returns to S1204 S1208.

[0061] If only a Ncell time repeats this operation and multiplier [of a cel 1 - Cel Ncell] S (i) is calculated, the loop-formation terminating condition of S1209 will be satisfied, and it will progress to S1210. The parameter X which expresses a **** ball with S1210 to (2) types only using the cel electrical potential difference of the low temperature used as S(i) =1 using the formula which multiplier S (i) joined is calculated, and it ends.

[0062] Moreover, since the temperature of each cel can be measured or presumed, when fuel cell stack temperature Tfc of S803 of drawing 8 is made into the temperature Tfc for every cel (i) and the steam partial pressure Bvapor calculated by S804 performs subsequent operations as Bvapor (i), precision can be raised more with this operation gestalt as well as the 3rd operation gestalt.

[0063] The [5th operation gestalt] Although considered as the configuration which calculates the parameter with which the temperature of each cel can be detected and a **** ball is expressed using the weight according to the temperature of each cel with the 3rd operation gestalt Since it is cooled more

and the cel of the direction near the inlet port of cooling water as a fuel cell tends to produce a **** ball, it is good also as a configuration which calculates the parameter which applies weight to the cel of the direction near the inlet port of cooling water, and expresses a **** ball with it.

[0064] Namely, with the 5th operation gestalt, supposing it pours cooling water for example, to the one where a cel number is larger from the one where the cel number of a fuel cell stack is smaller What is necessary is just to calculate the formula explained by S1108 of the 3rd operation gestalt by making weighting-factor [of a cel with the smaller cel number of a cooling water entrance side] W (i) larger than weighting-factor W (i+1) of a cel with a larger cel number, and setting up so that it may be set to W(i) >W (i+1).

[0065] The [6th operation gestalt] Although the temperature of each cel could be detected and the temperature of a cel considered as the configuration which calculates the parameter with which a **** ball is expressed based on the cel electrical potential difference of only a cel lower than a predetermined value with the 4th operation gestalt Since it is cooled more and the cel of the direction near the inlet port of cooling water as a fuel cell tends to produce a **** ball, it is good also as a configuration which calculates the parameter with which a **** ball is expressed only based on the cel electrical potential difference of the direction near the inlet port of cooling water.

[0066] namely, i if cooling water was poured with the 6th operation gestalt to the one where a cel number is larger from the one where the cel number of a fuel cell stack is smaller, when the number of cels is set to Ncell -- < (Ncell/3) -- it is -- what is necessary is to calculate a **** ball parameter only about the cel number i

[0067] The [7th operation gestalt] Although considered as the configuration which calculates the parameter with which the temperature of each cel can be detected and a **** ball is expressed using the weight according to the temperature of each cel with the 3rd operation gestalt Since temperature is the same as a fuel cell, the water condensed since the steam flow rate which the one where the gas pressure in a cel is higher solves and puts when saturated water vapor pressure is the same falls increases and it is easy to produce a **** ball, It is good also as a configuration which calculates the parameter which applies weight to a cel with higher gas pressure, and expresses a **** ball with it as the 7th operation gestalt.

[0068] The [8th operation gestalt] Although the temperature of each cel could be detected and the temperature of a cel considered as the configuration which calculates the parameter with which a **** ball is expressed based on the cel electrical potential difference of only a cel lower than a predetermined value with the 4th operation gestalt Since temperature is the same as a fuel cell, the water

condensed since the steam flow rate which can melt the one where the gas pressure in a cel is higher falls when saturated water vapor pressure is the same increases and it is easy to produce a **** ball, It is good also as a configuration which calculates the parameter with which a **** ball is expressed as the 8th operation gestalt only based on a cel electrical potential difference with higher gas pressure.

[0069] Although it came by the above operation gestalt as what detects the pressure of a fuel cell stack inlet port, and presumes the pressure for every cel, this is good also as a configuration which detects the pressure of a fuel cell stack outlet, and good also as a configuration which detects the pressure of both an inlet port and an outlet.

[0070] Moreover, although it came by the above operation gestalt as what detects a **** ball based on the electrical potential difference of a single cel, this is good also as a configuration which detects a **** ball using the electrical potential difference of a cel group which consists of two or more single cels.

[0071] Moreover, although the purge of an air pole came as what makes the throttle of control full open and usually performs it, this is good also as a configuration which prepares a purge valve apart from a throttle.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the basic block diagram of the control unit of the fuel cell concerning this invention.

[Drawing 2] It is the hardware configuration Fig. of the fuel cell system which applied the control unit of the fuel cell concerning this invention.

[Drawing 3] It is drawing showing the relation of (a) reference voltage of each cel, the cel electrical potential difference of (b) forward always, and the cel electrical potential difference at the time of (c) **** ball.

[Drawing 4] It is drawing showing the relation of (a) theoretical electrical potential difference of each cel, the reference voltage computed by (b) study, the cel electrical potential difference of (c) forward always, and the cel electrical potential difference at the time of (d) **** ball.

[Drawing 5] It is drawing showing the relation of the saturated water vapor pressure to temperature.

[Drawing 6] (a) It is drawing showing the relation of the rate of a pressure drop of the cel to drawing showing the relation between a cel number and the rate of a pressure drop of the cel to an air flow rate, (b) cel number, and a hydrogen flow rate.

[Drawing 7] It is the General flow chart which shows outline processing common to each operation gestalt.

[Drawing 8] It is a flow chart showing the procedure of the reference voltage operation in the 1st operation gestalt.

[Drawing 9] It is a flow chart showing the procedure of the reference voltage operation in the 2nd operation gestalt.

[Drawing 10] It is a flow chart showing the procedure of the **** ball parameter operation in the 1st operation gestalt.

[Drawing 11] It is a flow chart showing the procedure of the **** ball parameter operation in the 2nd operation gestalt.

[Drawing 12] It is a flow chart showing the procedure of the **** ball parameter operation in the 4th operation gestalt.

[Drawing 13] It is a flow chart showing the procedure of the water purge control in the 1st operation gestalt.

[Drawing 14] It is drawing showing the relation of the weight at the time of the **** ball parameter operation to the temperature of a cel.

[Description of Notations]

101 Operational Status Detection Means

102 Cel Electrical-Potential-Difference Detection Means

103 Reference Voltage Operation Means

104 **** Ball Condition Judging Means

105 Purge Control Means

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(71)出願人　000003997
日産自動車株式会社
神奈川県横浜市神奈川区宝町２番地
(72)発明者　鈴木　敬介
神奈川県横浜市神奈川区宝町２番地　日産自動車株式会社内
(74)代理人　100083806
弁理士　三好　秀和　（外８名）

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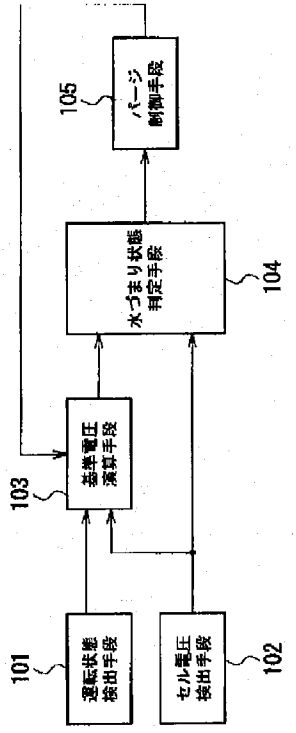
(54)【発明の名称】　燃料電池の制御装置および電気自動車

(57)【要約】
【課題】　経年変化による発電特性の変化や運転状態に係らず精度良く燃料電池の水づまりを検出する。
【解決手段】　運転状態検出手段１０１は、少なくとも燃料電池入口あるいは出口における燃料ガス及び酸化剤ガスの圧力を検出し、セル電圧検出手段１０２は単セルあるいは複数個の単セルからなるセル群の実電圧を検出する。基準電圧演算手段１０３は、運転状態検出手段１０１及びセル電圧検出手段１０２の出力に基づいてセル群の基準電圧を演算し、水づまり状態判定手段１０４はセル電圧検出手段１０２及び基準電圧演算手段１０３の出力に基づいてセルの水づまり状態を判定し、パージ制御手段１０５は水づまり状態判定手段１０４の判定結果出力に基づいてパージ制御を行う。



【特許請求の範囲】

【請求項１】　複数のセルを積層したセルスタックを備えた燃料電池の制御装置において、
少なくとも前記セルスタックの入口あるいは出口における燃料ガスと酸化剤ガスの圧力を検出する運転状態検出手段と、
該運転状態検出手段の出力に基づいて、単セルあるいは複数個の単セルからなるセル群の理論的な電圧値に基づく基準電圧を演算する基準電圧演算手段と、
燃料電池のセル群の実電圧を検出するセル電圧検出手段と、
該セル電圧検出手段の出力および前記基準電圧演算手段の出力に基づいてセルの水づまり状態を判定する水づまり状態判定手段と、
該水づまり状態判定手段の判定結果に基づいてセルに溜まった水を排出するための水パージ制御を行うパージ制御手段と、
を備えたことを特徴とする燃料電池の制御装置。

【請求項２】　前記水づまり状態判定手段は、前記基準電圧演算手段で演算したセル群の理論電圧値と、セル電圧検出手段で検出したセル群の電圧値とから、セル電圧の理論値からの変移の大きさを表わすパラメータを演算し、このパラメータの大きさによって水づまり状態を判定することを特徴とする請求項１記載の燃料電池の制御装置。

【請求項３】　前記基準電圧演算手段は、セル群の基準電圧値を演算する際に、水パージ制御を行った直後の所定期間のセル電圧検出値に基づいた学習値によって理論電圧値を補正して演算することを特徴とする請求項１または請求項２に記載の燃料電池の制御装置。

【請求項４】　セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が所定値よりも低いセルのセル電圧検出値に基づいて水づまりを判定することを特徴とする請求項１ないし請求項３のいずれか１項に記載の燃料電池の制御装置。

【請求項５】　セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が低いセルのセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを特徴とする請求項２ないし請求項４のいずれか１項に記載の燃料電池の制御装置。

【請求項６】　前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側の所定のセル電圧検出値に基づいて水づまりを判定することを特徴とする請求項１ないし請求項５のいずれか１項に記載の燃料電池の制御装置。

【請求項７】　前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側に近いセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを特徴とする請求項２ないし請求項５のいずれか１項に記載の燃料電池の制御装置。

【請求項８】　前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側の所定のセル電圧検出値に基づいて水づまりを判定することを特徴とする請求項１ないし請求項５のいずれか１項に記載の燃料電池の制御装置。

【請求項９】　前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側に近いセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを特徴とする請求項２ないし請求項７のいずれか１項に記載の燃料電池の制御装置。

【請求項１０】　前記パラメータは、セル群の基準電圧値とセル電圧検出手段で検出したセル群の実電圧値との差の自乗平均値であることを特徴とする請求項２ないし請求項９のいずれか１項に記載の燃料電池の制御装置。

【請求項１１】　燃料電池と、該燃料電池を制御するために請求項１ないし請求項１０のいずれか１項記載の燃料電池の制御装置とを備えたことを特徴とする電気自動車。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、燃料電池スタックの水づまりを検出して水パージを制御する燃料電池の制御装置および燃料電池を搭載した電気自動車に関する。

【０００２】

【従来の技術】燃料電池では、水素と酸素が反応した結果生じる生成水や、燃料ガスと酸化剤ガスに含まれる水蒸気が凝縮することにより生じる液水がセル内に滞留してしまうことがある。この場合、水が滞留したセルではガスの流れが阻害され、十分な水素、酸素が供給できず、セル電圧が低下してしまい、その結果出力が低下してしまうことになる。したがって、このような水の滞留（セルの水づまり）が生じた場合は、ガス流量を増加させて溜まった水を排出する「パージ」という作業を速やかに行い、燃料電池の各セル内を掃気して出力を回復する必要がある。

【０００３】従来の燃料電池スタックのセルの水づまりを検出して水パージを制御する技術として、特開平７－０２２０４７号公報、特開平９－２４５８２６号公報がある。前者の技術は、単セルに参照電極を設け、この参照電極を用いてアノードとカソードの単極電位を検出し、負荷変化に対するアノード、カソード双極の電位変化のパターンによりアノード、カソードどちらの極で水づまりを生じているかを推定し、水づまりを生じている極の反応体の流量を増加させるとともに加湿を停止させることで水づまりを解消する、というものである。

【０００４】また、後者の技術は、単セルまたは複数個の単セルからなるセルブロックの電圧の経時変化のパターンを燃料電池の種々の運転条件の場合に分けてあらか

じめ記憶装置に記憶させておき、単セル毎またはセルブロック毎の電圧の経時変化のパターンを測定し、得られた電圧の経時変化のパターンと記憶装置に記憶させたパターンとを比較して運転条件を判定し、水づまり、膜乾燥、酸化剤ガスの供給不足などの判定結果に応じて加湿量、ガス流量などを制御する、というものである。

【０００５】

【発明が解決しようとする課題】しかしながら、特開平７－０２２０４７号公報記載の技術は、一つあるいは複数のセルに参照電極を設け、参照電極に対するセルのアノード、カソードの単極電位から水づまりを推定する構成であるため、燃料電池の運転状態が変化した場合の単極電位の変化が各セルの理論的に出力可能な電圧が変化したものなのか、水づまりによって変化したものなのかの判別が難しく、さまざまな運転状態で精度良く水づまりを検出することができない、という問題点があった。

【０００６】また、特開平９－２４５８２６号公報記載の技術は、単セル毎またはセルブロック毎の電圧の経時変化のパターンを検出し、その検出値をあらかじめ記憶装置に記憶させたパターンと比較して運転条件を判定する構成であるため、長い時間での経年変化によりそもそもの燃料電池の特性が劣化してきた場合に、その経年変化による特性変化と水づまり等による特性の経時変化を分離することができないため、水づまり等の運転条件の判定精度が低下する、という問題点があった。

【０００７】以上の問題点に鑑み本発明の目的は、運転状態に係らず精度良く燃料電池の水づまりを検出することができる燃料電池の制御装置を提供することである。

【０００８】また本発明の目的は、経年変化による燃料電池の発電特性の変化があっても精度良く水づまりを検出することができる燃料電池の制御装置を提供することである。

【０００９】さらに本発明の目的は、燃料電池を搭載した電気自動車において、燃料電池の水づまりを精度良く検出して燃費および運転性を向上させた電気自動車を提供することである。

【００１０】

【課題を解決するための手段】上記目的を達成するため、請求項１記載に発明は、複数のセルを積層したセルスタックを備えた燃料電池の制御装置において、少なくとも前記セルスタックの入口あるいは出口における燃料ガスと酸化剤ガスの圧力を検出する運転状態検出手段と、該運転状態検出手段の出力に基づいて、単セルあるいは複数個の単セルからなるセル群の理論的な電圧値に基づく基準電圧を演算する基準電圧演算手段と、燃料電池のセル群の実電圧を検出するセル電圧検出手段と、該セル電圧検出手段の出力および前記基準電圧演算手段の出力に基づいてセルの水づまり状態を判定する水づまり状態判定手段と、該水づまり状態判定手段の判定結果に基づいてセルに溜まった水を排出するための水パージ制御を行うパージ制御手段と、を備えたことを要旨とする。

【００１１】上記目的を達成するため、請求項２記載に発明は、請求項１記載の燃料電池の制御装置において、前記水づまり状態判定手段は、前記基準電圧演算手段で演算したセル群の理論電圧値と、セル電圧検出手段で検出したセル群の電圧値とから、セル電圧の理論値からの変移の大きさを表わすパラメータを演算し、このパラメータの大きさによって水づまり状態を判定することを要旨とする。

【００１２】上記目的を達成するため、請求項３記載に発明は、請求項１または請求項２に記載の燃料電池の制御装置において、前記基準電圧演算手段は、セル群の基準電圧値を演算する際に、水パージ制御を行った直後の所定期間のセル電圧検出値に基づいた学習値によって理論電圧値を補正して演算することを要旨とする。

【００１３】上記目的を達成するため、請求項４記載に発明は、請求項１ないし請求項３のいずれか１項に記載の燃料電池の制御装置において、セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が所定値よりも低いセルのセル電圧検出値に基づいて水づまりを判定することを要旨とする。

【００１４】上記目的を達成するため、請求項５記載に発明は、請求項２ないし請求項４のいずれか１項に記載の燃料電池の制御装置において、セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が低いセルのセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを要旨とする。

【００１５】上記目的を達成するため、請求項６記載に発明は、請求項１ないし請求項５のいずれか１項に記載の燃料電池の制御装置において、前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側の所定のセル電圧検出値に基づいて水づまりを判定することを要旨とする。

【００１６】上記目的を達成するため、請求項７記載に発明は、請求項２ないし請求項５のいずれか１項に記載の燃料電池の制御装置において、前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側に近いセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを要旨とする。

【００１７】上記目的を達成するため、請求項８記載に発明は、請求項１ないし請求項５のいずれか１項に記載の燃料電池の制御装置において、前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側の所定のセル電圧検出値に基づいて水づまりを判定することを要旨とする。

【００１８】上記目的を達成するため、請求項９記載に発明は、請求項２ないし請求項７のいずれか１項に記載

の燃料電池の制御装置において、前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側に近いセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定することを要旨とする。

【００１９】上記目的を達成するため、請求項１０記載に発明は、請求項２ないし請求項９のいずれか１項に記載の燃料電池の制御装置において、前記パラメータは、セル群の基準電圧値とセル電圧検出手段で検出したセル群の実電圧値との差の自乗平均値であることを要旨とする。

【００２０】上記目的を達成するため、請求項１１記載に発明は、燃料電池と、該燃料電池を制御するために請求項１ないし請求項１０のいずれか１項記載の燃料電池の制御装置とを備えたことを要旨とする電気自動車である。

【００２１】

【発明の効果】請求項１の発明によれば、複数のセルを積層したセルスタックを備えた燃料電池の制御装置において、少なくとも前記セルスタックの入口あるいは出口における燃料ガスと酸化剤ガスの圧力を検出する運転状態検出手段と、該運転状態検出手段の出力に基づいて、単セルあるいは複数個の単セルからなるセル群の理論的な電圧値に基づく基準電圧を演算する基準電圧演算手段と、燃料電池のセル群の実電圧を検出するセル電圧検出手段と、該セル電圧検出手段の出力および前記基準電圧演算手段の出力に基づいてセルの水づまり状態を判定する水づまり状態判定手段と、該水づまり状態判定手段の判定結果に基づいてセルに溜まった水を排出するための水パージ制御を行うパージ制御手段と、を備えたことにより、運転状態が変化してもまた経年変化により燃料電池特性が変化しても、運転状態に応じた基準電圧と実際のセル電圧とからセルの水づまりを精度よく検出することができるという効果がある。

【００２２】請求項２の発明によれば、請求項１の発明の効果に加えて、前記水づまり状態判定手段は、前記基準電圧演算手段で演算したセル群の理論電圧値と、セル電圧検出手段で検出したセル群の電圧値とから、セル電圧の理論値からの変移の大きさを表わすパラメータを演算し、このパラメータの大きさによって水づまり状態を判定するようにしたので、さらにパラメータによって水づまりを正確に判定することができるという効果がある。

【００２３】請求項３の発明によれば、請求項１または請求項２の発明の効果に加えて、前記基準電圧演算手段は、セル群の基準電圧値を演算する際に、水パージ制御を行った直後の所定期間のセル電圧検出値に基づいた学習値によって理論電圧値を補正して演算するようにしたので、経年変化により燃料電池の電圧値が理論電圧値からずれてきた場合でも、精度良く水づまりを検出することができるという効果がある。

【００２４】請求項４の発明によれば、請求項１ないし請求項３の発明の効果に加えて、セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が所定値よりも低いセルのセル電圧検出値に基づいて水づまりを判定するようにしたので、比較的水の凝縮量が多く水が溜まりやすい低温部のセルのみのセル電圧検出値に基づいて水づまりを判定することができ、セル電圧の検出周期を高速にすることができ、その結果、精度良く水づまりを検出することができるという効果がある。

【００２５】請求項５の発明によれば、請求項２ないし請求項４の発明の効果に加えて、セル群の温度分布を検出する温度検出手段を備え、前記水づまり状態判定手段は、温度が低いセルのセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定するようにしたので、さらに感度良く水づまりを検出することができるという効果がある。

【００２６】請求項６の発明によれば、請求項１ないし請求項５の発明の効果に加えて、前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側の所定のセル電圧検出値に基づいて水づまりを判定するようにしたので、比較的水の凝縮量が多く水が溜まりやすい燃料電池スタックの冷却水入口側のセルのセル電圧の検出周期を高速にすることができ、その結果、精度良く水づまりを検出することができるという効果がある。

【００２７】請求項７の発明によれば、請求項２ないし請求項５の発明の効果に加えて、前記水づまり状態判定手段は、燃料電池スタックの冷却水入口側に近いセル電圧検出値に基づいた前記パラメータの演算値に、より大きな重みを掛けて水づまりを判定するようにしたので、比較的水の凝縮量が多く水が溜まりやすい燃料電池スタックの冷却水入口側に近いセル電圧検出値に基づいたパラメータ演算値により大きな重みを掛けることができ、感度良く水づまりを検出することができるという効果がある。

【００２８】請求項８の発明によれば、請求項１ないし請求項５の発明の効果に加えて、前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側の所定のセル電圧検出値に基づいて水づまりを判定するようにしたので、飽和水蒸気流量が低く比較的水が溜まりやすいガス圧力の高いセルのセル電圧検出値のみに基づいて水づまりを判定できるようになり、水が溜まりやすいセルのセル電圧の検出周期を高速にすることができ、その結果、精度良く水づまりを検出することができるという効果がある。

【００２９】請求項９の発明によれば、請求項２ないし請求項７の発明の効果に加えて、前記水づまり状態判定手段は、燃料電池スタックのセルのうちガス圧力が高い側に近いセル電圧検出値に基づいた前記パラメータの演

算値に、より大きな重みを掛けて水づまりを判定するようにしたので、飽和水蒸気流量が低く比較的水が溜まりやすいガス圧力の高いセルのセル電圧検出値に基づいたパラメータ演算値に、より大きな重みを掛けて水づまりを判定することができるようになり、感度良く水づまりを検出することができるという効果がある。

【００３０】請求項１０の発明によれば、請求項２ないし請求項９の発明の効果に加えて、前記パラメータは、セル群の基準電圧値とセル電圧検出手段で検出したセル群の実電圧値との差の自乗平均値としたので、簡単な演算で精度良く水づまりを検出することができるという効果がある。

【００３１】請求項１１の発明によれば、燃料電池と、該燃料電池を制御するために請求項１ないし請求項１０のいずれか１項記載の燃料電池の制御装置とを備えたことにより、運転状態が変化してもまた経年変化により燃料電池特性が変化しても、セルの水づまりを精度よく検出することができ、電気自動車の燃費および運転性を向上させることができるという効果がある。

【００３２】

【発明の実施の形態】次に、図面を参照して、本発明を詳細に説明する。実施形態の説明の前に、本発明の基本概念を説明する。燃料電池のセルの電圧が低下する要因としては、空気極での酸素分圧の低下や水素極での水素分圧の低下もあるが、これらの分圧の低下がセル全体の電圧低下として現れるのに対して、セルの水づまりによる影響は特定のセルあるいはセル群の電圧低下、すなわちセル電圧のばらつきとして現れる傾向がある。したがって、水づまりが生じていない時のセル群の基準電圧からの実電圧のばらつきの大きさを演算すれば、水づまりを正確に検出することができ、その結果、不要な水パージを抑制するとともに、水パージが必要な場合に水パージを確実に実行することができる。

【００３３】また、セル群の基準電圧は経年変化により理論電圧からずれていることがあるが、水パージ制御を実行した直後の水づまりの無い状態でのセル群の実電圧値から経年変化によるずれを学習し基準電圧の演算に反映させれば、経年変化にかかわらず水づまりを精度良く検出し、水パージ制御を確実に実行することができる。

【００３４】図１は、本発明に係る燃料電池の制御装置の基本構成を示す構成図である。同図において、燃料電池の制御装置は、少なくとも燃料電池入口あるいは出口における燃料ガスおよび酸化剤ガスの圧力を検出する運転状態検出手段１０１と、単セルあるいは複数個の単セルからなるセル群の実電圧を検出するセル電圧検出手段１０２と、運転状態検出手段１０１、セル電圧検出手段１０２及び後述する１０５の出力に基づいてセル群の基準電圧を演算する基準電圧演算手段１０３と、セル電圧検出手段１０２および基準電圧演算手段１０３の出力に基づいてセルの水づまり状態を判定する水づまり状態判定手段１０４と、水づまり状態判定手段１０４の判定結果出力に基づいてパージ制御を行うパージ制御手段１０５とを備えている。

【００３５】図２は、この発明に係る燃料電池の制御装置が適用される燃料電池システムの構成を示すシステム構成図であり、特に限定されないが電気自動車に好適な燃料電池システムである。

【００３６】図２に示すように、本発明が適用される燃料電池システムは、図示しない燃料極及び空気極を有し燃料ガスである水素と空気中の酸素との電気化学反応により発電する燃料電池スタック（燃料電池本体）２０１と、水素及び空気を加湿する加湿器２０２と、外部から取り入れた空気を圧縮して加湿器２０２へ送るコンプレッサ２０３と、高圧水素の流量を制御する可変バルブ２０４と、空気の圧力及び流量を制御するスロットル２０５と、水素を外部に排気するパージ弁２０６と、加湿器２０２へ純水を供給する純水ポンプ２０７と、燃料電池入口の空気圧力を検出する圧力センサ２０８と、燃料電池入口の水素圧力を検出する圧力センサ２０９と、セル電圧検出電極２１１ａ、２１１ｂ、…、２１１ｚと、燃料電池を制御するコントローラ２１０とを備えている。

【００３７】図１と図２の対応関係は以下の通りである。図１の運転状態検出手段１０１は、図２の空気圧力を検出する圧力センサ２０８及び水素圧力を検出する圧力センサ２０９に相当し、図１のセル電圧検出手段１０２は、セル電圧検出電極２１１ａ、２１１ｂ、…、２１１ｚに相当する。図１の基準電圧演算手段１０３、水づまり状態判定手段１０４、及びパージ制御手段１０５は、コントローラ２１０に相当する。

【００３８】コンプレッサ２０３は空気を圧縮して加湿器２０２へ送り、加湿器２０２では純水ポンプ２０７で供給された純水で空気を加湿し、加湿された空気が燃料電池スタック２０１へ送り込まれる。高圧水素は可変バルブ２０４で流量が制御されて加湿器２０２へ送られ、加湿器２０２では空気と同様に純水ポンプ２０７で供給された純水で水素を加湿し、加湿された水素が燃料電池スタック２０１へ送り込まれる。燃料電池スタック２０１では送り込まれた空気と水素を反応させて発電を行い、電流（電力）を車両等の外部システムへ供給する。燃料電池スタック２０１で反応に使用した残りの空気は、スロットル２０５で圧力制御が行われた後、大気へ排出される。

【００３９】また、反応に使用した残りの水素は燃料電池スタック２０１から排出されるが、加湿器２０２の上流へ還流されて発電に再利用する。いま、燃料電池入口の空気圧力を検出する圧力センサ２０８と水素圧力を検出する圧力センサ２０９を備え、これらの信号は燃料電池のセル群のセル電圧とともにコントローラ２１０へ読み込まれる。コントローラ２１０では、読み込んだ値からセルの水づまりの状況を判定し、水づまりが生じてい

ると判定した場合には、空気側のスロットル２０５と水素のパージ弁２０６を開弁し、燃料電池内部に溜まった水を外部に排出し、燃料電池の出力が回復するように制御を行う。

【００４０】図３は、セル番号をｉとしたときの各セルの（ａ）基準電圧値（＝理論電圧値Ｖｅｓｔ０（ｉ））と（ｂ）正常時、（ｃ）水づまり時の実セル電圧Ｖｃｅｌｌ（ｉ）の変化の様子を示す図である。燃料電池のセル番号ｉの理論電圧値Ｖｅｓｔ０（ｉ）は、「電気化学概論」（松田・岩倉共著、丸善株式会社）、「新しい電気化学」（電気化学会編、培風館）等記載の「ネルンストの式」、「分極（活性分極、濃度分極）」、「限界電流密度」などの記載に基づいて、酸素分圧（Ｂｏ2）、水素分圧（Ｂｈ2）、取出し電流（Ｉｃ）、スタック温度（Ｔｆｃ）から（１）式に示す理論式によって算出することができる。

【００４１】

【数１】

$$Vest0 = K0 - T_{fc}\cdot\left\{K1\cdot\ln(B_{h2}) + K2\cdot\ln(B_{o2}) + K3\cdot\ln(Ic)\right\} + K4\cdot T_{fc}$$

$$+K5\cdot Ic + T_{fc}\cdot K1\left\{\ln\left(\frac{I_{h2,L}-Ic}{I_{h2,L}}\right) + \ln\left(\frac{I_{o2,L}-Ic}{I_{o2,L}}\right)^{\frac{1}{2}}\right\} \quad \cdots(1)$$

ここで、Ｋ１からＫ５は定数、Ｉｈ2,ＬはＢｈ2、Ｔｆｃから決まる水素限界電流密度、Ｉｏ2,ＬはＢｏ2、Ｔｆｃから決まる酸素限界電流密度である。

【００４２】また、分圧Ｂｈ2，Ｂｏ2は、図５でスタック温度から決まる水蒸気分圧と、スタック入口の空気圧力Ｐｏ2、水素圧力Ｐｈ2と空気中の酸素濃度から求めることができる。燃料電池内の各セルでの圧力は内部の配管の圧損により出口側に近づくに従い徐々に低下するため、この圧損特性を事前に調べておけば、理論式から求めた各セル毎の理論電圧値は、図３（ａ）のようになる。ここで、各セル電圧の基準値からのばらつきの大きさを示すパラメータを次の（２）式によって求めるものとする。

【００４３】

【数２】

$$X = \frac{1}{Ncell}\sum_{i=1}^{Ncell}\left\{Vcell(i) - Vest(i)\right\}^2 \quad \cdots(2)$$

いま、図３（ｂ）に示すように各セルの実電圧値が基準電圧値とほぼ一致していれば（２）式のパラメータ値は小さくなり、水づまりは生じていない、と判断できるが、図３（ｃ）のように検出されれば理論電圧値から大きくずれたセルがあるため、（２）式のパラメータ値が大きくなり水づまりを生じていると判断することができる。

【００４４】図４には、各セルの（ａ）理論電圧値Ｖｅｓｔ０（ｉ）と、（ｂ）経年変化による特性ずれを学習値で補正した基準電圧値Ｖｅｓｔ（ｉ）、（ｃ）正常時、（ｄ）水づまり時の実セル電圧Ｖｃｅｌｌ（ｉ）の様子を示す。図３の場合と同様に、スタック入口空気圧力Ｐｏ2、水素圧力Ｐｈ2、スタック温度Ｔｆｃ、取出し電流Ｉｃ、圧損特性から（１）式を用いてまず各セルの理論電圧値Ｖｅｓｔ０（ｉ）を演算する（図４（ａ））。

【００４５】また、水パージを行った直後には各セルの実電圧値Ｖｃｅｌｌ（ｉ）に基づき、次の（３）式

【数３】

$$k(i,p) = \alpha\cdot k(i,p-1) + (1-\alpha)\cdot\frac{1}{N}\sum_{n=1}^{N}\frac{Vcell(i,n)}{Vest0(i)} \quad \cdots(3)$$

を用いて経年変化に対する補正係数の学習を行い、その学習値を用いて基準電圧値Ｖｅｓｔ（ｉ）を次の（４）式

【数４】

$$Vest(i) = k(i,p)\cdot Vest0(i) \quad \cdots(4)$$

を用いて演算する。ここで、

ｋ（ｉ，ｐ）：セルｉのＰ回目の水パージ後の学習値

α　：学習値更新の移動平均係数（０＜α＜１）

Ｎ　：一度の学習に用いるデータ数

である。

【００４６】経年変化があった場合、各セルでの基準電圧値は理論電圧値からずれることがあるが、（３）式の学習値で理論電圧値を補正することで、図４（ｂ）のような基準電圧値を求めることができる。つぎに（４）式で求めた基準電圧値Ｖｅｓｔ（ｉ）と各セルの実電圧値Ｖｃｅｌｌ（ｉ）から（２）式を用いてセル電圧のばらつきの度合いを示すパラメータを演算する。図４（ｃ）に示すように各セルの実電圧値が基準電圧値とほぼ一致していれば（２）式のパラメータ値は小さくなり、水づまりは生じていない、と判断できるが、図４（ｄ）のよ

うに検出されれば理論電圧値から大きくずれたセルがあるため、（２）式のパラメータ値が大きくなり水づまりを生じていると判断することができる。

【００４７】また、ここでは単セルの電圧に基づいた検出について説明したが、これは複数個の単セルからなるセル群の電圧を用いても同様に検出することが可能である。

【００４８】〔第１実施形態〕次に、図１、図２に構成を示した第１実施形態の動作を、図７，図８，図１０，図１３のフローチャートを参照して詳細に説明する。図７が全体の動作を示すゼネラルフローチャートであり、図２のコントローラ２１０によって、所定時間毎（例えば１０［ｍｓ］毎）に実行される。

【００４９】ステップ（以下、ステップをＳと略す）７０１，Ｓ７０２では燃料電池スタック入口の空気圧力Ｐａｉｒ０、水素圧力Ｐｈ２０を検出し、Ｓ７０３ではいま燃料電池から取出されている電流値Ｉｃを検出する。Ｓ７０４では、検出した値に基づいて各セル（ｉ＝１～Ｎｃｅｌｌ）の基準電圧値Ｖｅｓｔ(i)を演算し、Ｓ７０５では各セルの実電圧値Ｖｃｅｌｌ（ｉ）を検出する。Ｓ７０６では基準電圧値と実電圧値に基づいて水づまりを表わすパラメータを演算し、Ｓ７０７では、演算したパラメータに応じて水パージ制御を実行して、終了する。

【００５０】図８は、図７のＳ７０４における基準電圧値Ｖｅｓｔ(i)演算の手続きの内容を示す。

【００５１】Ｓ８０１では、検出した燃料電池スタック入口の空気圧力Ｐａｉｒ０と空気極の圧損特性から、各セルでの空気圧力Ｐａｉｒ（ｉ）を推定する。ここで、圧損特性は現物の特性を事前に実験で調べておき、図６（ａ）に示すような流量（あるいは出力）とセル番号から圧力低下率が求まるマップで与えるものとする。Ｓ８０２では、検出した燃料電池スタック入口の水素圧力Ｐh20と水素極の圧損特性から、各セルでの水素圧力Ｐh2（ｉ）を推定する。水素の圧損特性は空気の場合と同様に図６（ｂ）で与えるものとする。Ｓ８０３では燃料電池スタックの温度Ｔfcを検出し、Ｓ８０４では温度と図５の水蒸気分圧特性から水蒸気分圧Ｂｖａｐｏｒを演算する。Ｓ８０５では、各セルでの空気圧力推定値Ｐo2（ｉ）、水蒸気分圧Ｂｖａｐｏｒ、空気中の酸素濃度Ｒo2から各セルでの酸素分圧Ｂo2（ｉ）を演算する。Ｓ８０６では、各セルでの水素圧力推定値Ｐh2（ｉ）、水蒸気分圧Ｂｖａｐｏｒから各セルでの水素分圧Ｂh2（ｉ）を演算する。Ｓ８０７では、（１）式に基づいて各セルでの理論電圧値Ｖｅｓｔ０（ｉ）を演算し、Ｓ８０８では各セルでの基準電圧値Ｖｅｓｔ（ｉ）に理論電圧値Ｖｅｓｔ０（ｉ）を代入し終了する。

【００５２】図１０には、図７のＳ７０６における水づまりパラメータ演算の手続きの内容を示す。Ｓ１００１では、図７のＳ７０４で演算した各セルの基準電圧Ｖｅｓｔ（ｉ）を読み込み、Ｓ１００２では、図７のＳ７０５で演算した各セルの実電圧Ｖｃｅｌｌ（ｉ）を読み込む。Ｓ１００３では（２）式を用いて、水づまりを表わすパラメータＸを演算し、終了する。

【００５３】図１３には、図７のＳ７０７における水パージ制御実行の手続きの内容を示す。Ｓ１３０１では、パージ実行中を表わすフラグＰＦｌａｇの値を判断する。Ｓ１３０１でパージ実行中ではない（ＰＦｌａｇ＝０）と判断した場合にはＳ１３０２へ進み、パラメータＸが水づまりを判定するしきい値Ｘｐｕｒｇｅより大きいかどうかを判断する。Ｓ１３０２で水づまり（Ｘ＞Ｘｐｕｒｇｅ）と判断したら、Ｓ１３０３で空気スロットルを全開にし、Ｓ１３０４で水素パージ弁を全開にし、Ｓ１３０５でＰＦｌａｇ＝１とし、Ｓ１３０６でｃｏｕｎｔｅｒ＝０とし、終了する。また、Ｓ１３０２で、水づまりでない（Ｘ≦Ｘｐｕｒｇｅ）と判断した場合はそのまま終了する。Ｓ１３０１でパージ実行中である（ＰＦｌａｇ＝１）と判断したら、Ｓ１３０７でｃｏｕｎｔｅｒに１を足し、Ｓ１３０８へ進む。Ｓ１３０８では、ｃｏｕｎｔｅｒがパージ実行の時間Ｔｐｕｒｇｅより大きいかどうか判断し、大きい場合はＳ１３０９で全開にしてあった空気スロットルを通常制御にもどし、Ｓ１３１０で水素パージ弁を全開し、Ｓ１３１１でパージ実行中を表わすフラグＰＦｌａｇ＝０とし、終了する。また、Ｓ１３０８でｃｏｕｎｔｅｒがパージ実行の時間Ｔｐｕｒｇｅより大きいと判断されなかった時は、そのまま終了する。

【００５４】〔第２実施形態〕第２の実施形態を、図７，図９，図１０，図１３のフローチャートに示す。図７，図１０，図１３は第１の実施形態と同様なので、図９についてのみ説明する。

【００５５】図９には、図７のＳ７０４における基準電圧（Ｖｅｓｔ（ｉ））演算の手続きの内容を示す。Ｓ９０１からＳ９０７は、図８のＳ８０１から８０７と同様なので省略する。Ｓ９０８では、パージ制御実行後の所定時間のデータに基づき（３）式によって算出した補正係数ｋ（ｉ，ｐ）を読み込み、Ｓ９０９では各セルでの理論電圧値Ｖｅｓｔ０（ｉ）に各セルの補正係数を掛けた値を基準電圧値Ｖｅｓｔ（ｉ）に代入し終了する。

【００５６】〔第３実施形態〕第３の実施形態を、図７，図８（あるいは図９）、図１１，図１３のフローチャートに示す。本実施形態は、各セルの温度が計測あるいは推定できる場合の実施形態である。図７，図８，図１３は第１の実施形態と同様なので、図１１についてのみ説明する。

【００５７】図１１には、図７のＳ７０６における水づまりパラメータ演算の手続きの内容を示す。Ｓ１１０１では、図７のＳ７０４で演算した各セルの基準電圧Ｖｅｓｔ（ｉ）を読み込み、Ｓ１１０２では、図７のＳ７０５で演算した各セルの実電圧Ｖｃｅｌｌ（ｉ）を読み込

む。Ｓ１１０３ではセル番号を表わす変数ｉの初期値をｉ＝１に設定し、Ｓ１１０４では各セルの温度Ｔｃｅｌｌ（ｉ）を検出する。Ｓ１１０５では図１４に示すテーブルデータに基づき、セル温度に応じた重み係数Ｗ（ｉ）を演算する。Ｓ１１０６では変数ｉを１増加し、Ｓ１１０７では変数ｉがＮｃｅｌｌより大きいかを判断し、大きくない場合はＳ１１０４へ戻る。この演算をＮｃｅｌｌだけ繰り返し、セル１～セルＮｃｅｌｌの重み係数Ｗ（ｉ）を演算したら、Ｓ１１０７のループ終了条件が成立し、Ｓ１１０８へ進む。Ｓ１１０８では（２）式に重み係数Ｗ（ｉ）が加わった式を用いて、水づまりを表わすパラメータＸを演算し、終了する。

【００５８】また、この実施形態では各セルの温度を計測あるいは推定できるので、図８のＳ８０３での燃料電池スタック温度Ｔｆｃを各セル毎の温度Ｔｆｃ（ｉ）とし、Ｓ８０４で演算する水蒸気分圧ＢｖａｐｏｒもＢｖａｐｏｒ（ｉ）として以降の演算を行うことにより、より精度を上げることができる。

【００５９】〔第４実施形態〕第４の実施形態を、図７，図８（あるいは図９）、図１２，図１３のフローチャートに示す。本実施形態も第３の実施形態と同様に各セルの温度が計測あるいは推定できる場合の実施形態である。図７，図８，図１３は第１の実施形態と同様なので、図１２についてのみ説明する。

【００６０】図１２には、図７のＳ７０６における水づまりパラメータ演算の手続きの内容を示す。図１２において、Ｓ１２０１では、図７のＳ７０４で演算した各セルの基準電圧Ｖｅｓｔ（ｉ）を読み込み、Ｓ１２０２では、図７のＳ７０５で演算した各セルの実電圧Ｖｃｅｌｌ（ｉ）を読み込む。Ｓ１２０３ではセル番号を表わす変数ｉの初期値をｉ＝１とし、Ｓ１２０４では各セルの温度Ｔｃｅｌｌ（ｉ）を検出する。Ｓ１２０５では検出した温度Ｔｃｅｌｌ（ｉ）が所定の温度Ｔｄｅｗよりも低いかどうかを判定する。Ｓ１２０５でセル温度Ｔｃｅｌｌ（ｉ）がＴｄｅｗより低いと判断した場合にはＳ１２０６へ進み、係数Ｓ（ｉ）に１を代入しＳ１２０８へ進む。Ｓ１２０５でセル温度Ｔｃｅｌｌ（ｉ）がＴｄｅｗより低いと判断しなかった場合にはＳ１２０７へ進み、係数Ｓ（ｉ）に０を代入しＳ１２０８へ進む。Ｓ１２０８では変数ｉを１増加し、Ｓ１２０９では変数ｉがＮｃｅｌｌより大きいかを判断し、大きくない場合はＳ１２０４へ戻る。

【００６１】この演算をＮｃｅｌｌ回だけ繰り返し、セル１～セルＮｃｅｌｌの係数Ｓ（ｉ）を演算したら、Ｓ１２０９のループ終了条件が成立し、Ｓ１２１０へ進む。Ｓ１２１０では（２）式に係数Ｓ（ｉ）が加わった式を用いて、Ｓ（ｉ）＝１となった低温のセル電圧のみを用いて水づまりを表わすパラメータＸを演算し、終了する。

【００６２】また、第３の実施形態と同様に、この実施形態では各セルの温度を計測あるいは推定できるので、図８のＳ８０３での燃料電池スタック温度Ｔｆｃを各セル毎の温度Ｔｆｃ（ｉ）とし、Ｓ８０４で演算する水蒸気分圧ＢｖａｐｏｒもＢｖａｐｏｒ（ｉ）として以降の演算を行うことにより、より精度を上げることができる。

【００６３】〔第５実施形態〕第３の実施形態では、各セルの温度が検出でき、各セルの温度に応じた重みを用いて水づまりを表わすパラメータを演算する構成としたが、燃料電池としては冷却水の入口に近い方のセルがより冷却されて水づまりを生じ易いため、冷却水の入口に近い方のセルに重みを掛けて水づまりを表わすパラメータを演算する構成としても良い。

【００６４】即ち、第５実施形態では、例えば、燃料電池スタックのセル番号の小さい方からセル番号の大きい方へ冷却水を流すとすれば、冷却水入口側のセル番号の小さい方のセルの重み係数Ｗ（ｉ）をセル番号の大きい方のセルの重み係数Ｗ（ｉ＋１）より大きくし、Ｗ（ｉ）＞Ｗ（ｉ＋１）となるように設定して、第３実施形態のＳ１１０８で説明した式を計算すればよい。

【００６５】〔第６実施形態〕第４の実施形態では、各セルの温度が検出でき、セルの温度が所定値より低いセルのみのセル電圧に基づいて水づまりを表わすパラメータを演算する構成としたが、燃料電池としては冷却水の入口に近い方のセルがより冷却されて水づまりを生じ易いため、冷却水の入口に近い方のセル電圧のみに基づいて水づまりを表わすパラメータを演算する構成としても良い。

【００６６】即ち、第６実施形態では、燃料電池スタックのセル番号の小さい方からセル番号の大きい方へ冷却水を流すとすれば、セル数をＮｃｅｌｌとしたとき、例えば、ｉ＜（Ｎｃｅｌｌ／３）であるセル番号ｉについてのみ、水づまりパラメータを演算すればよい。

【００６７】〔第７実施形態〕第３の実施形態では、各セルの温度が検出でき、各セルの温度に応じた重みを用いて水づまりを表わすパラメータを演算する構成としたが、燃料電池としては温度が同じで飽和水蒸気圧が同じ場合、セル内のガス圧力が高い方がとけ込める水蒸気流量が低下するため凝縮する水が増加し、水づまりを生じ易いため、第７実施形態として、ガス圧力の高い方のセルに重みを掛けて水づまりを表わすパラメータを演算する構成としても良い。

【００６８】〔第８実施形態〕第４の実施形態では、各セルの温度が検出でき、セルの温度が所定値より低いセルのみのセル電圧に基づいて水づまりを表わすパラメータを演算する構成としたが、燃料電池としては温度が同じで飽和水蒸気圧が同じ場合、セル内のガス圧力が高い方が溶け込める水蒸気流量が低下するため凝縮する水が増加し、水づまりを生じ易いため、第８実施形態として、ガス圧力の高い方のセル電圧のみに基づいて水づまりを表わすパラメータを演算する構成としても良い。

【００６９】以上の実施形態では、燃料電池スタック入口の圧力を検出して各セル毎の圧力を推定するものとしてきたが、これは燃料電池スタック出口の圧力を検出する構成としてもよいし、入口、出口両方の圧力を検出する構成としてもよい。

【００７０】また、以上の実施形態では単セルの電圧に基づいて水づまりを検出するものとしてきたが、これは複数個の単セルからなるセル群の電圧を用いて水づまりを検出する構成としてもよい。

【００７１】また、空気極のパージは通常制御のスロットルを全開にして行うものとしてきたが、これはスロットルとは別にパージバルブを設ける構成としてもよい。

【図面の簡単な説明】

【図１】本発明に係る燃料電池の制御装置の基本構成図である。

【図２】本発明に係る燃料電池の制御装置を適用した燃料電池システムのハードウェア構成図である。

【図３】各セルの（ａ）基準電圧と、（ｂ）正常時のセル電圧、（ｃ）水づまり時のセル電圧の関係を表わす図である。

【図４】各セルの（ａ）理論電圧と、（ｂ）学習により算出した基準電圧と、（ｃ）正常時のセル電圧、（ｄ）水づまり時のセル電圧の関係を表わす図である。

【図５】温度に対する飽和水蒸気圧の関係を表わす図である。

【図６】（ａ）セル番号及び空気流量に対するセルの圧力低下率の関係を表わす図、（ｂ）セル番号及び水素流量に対するセルの圧力低下率の関係を表わす図である。

【図７】各実施形態に共通の概略処理を示すゼネラルフローチャートである。

【図８】第１実施形態における基準電圧演算の手続きを表わすフローチャートである。

【図９】第２実施形態における基準電圧演算の手続きを表わすフローチャートである。

【図１０】第１実施形態における水づまりパラメータ演算の手続きを表わすフローチャートである。

【図１１】第２実施形態における水づまりパラメータ演算の手続きを表わすフローチャートである。

【図１２】第４実施形態における水づまりパラメータ演算の手続きを表わすフローチャートである。

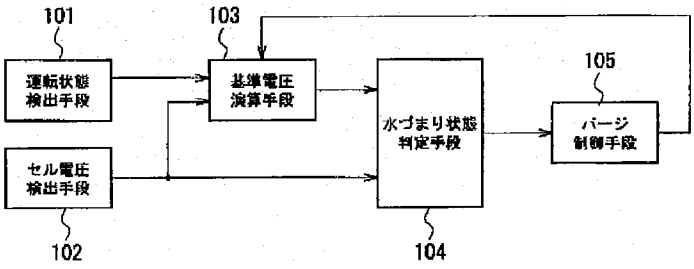
【図１３】第１実施形態における水パージ制御の手続きを表わすフローチャートである。

【図１４】セルの温度に対する水づまりパラメータ演算時の重みの関係を表わす図である。

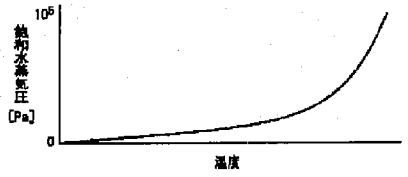
【符号の説明】

１０１　運転状態検出手段
１０２　セル電圧検出手段
１０３　基準電圧演算手段
１０４　水づまり状態判定手段
１０５　パージ制御手段

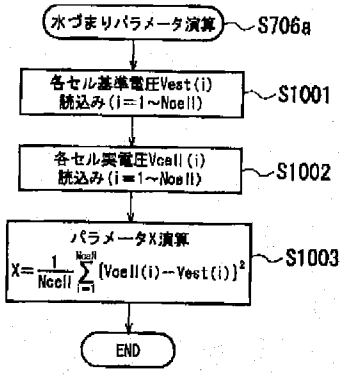
【図１】



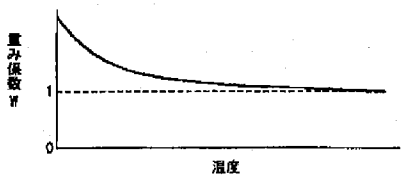
【図５】



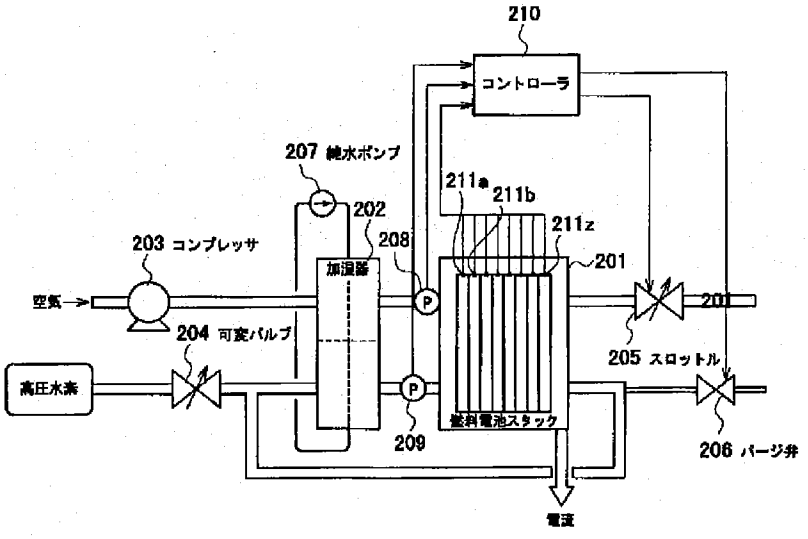
【図１０】



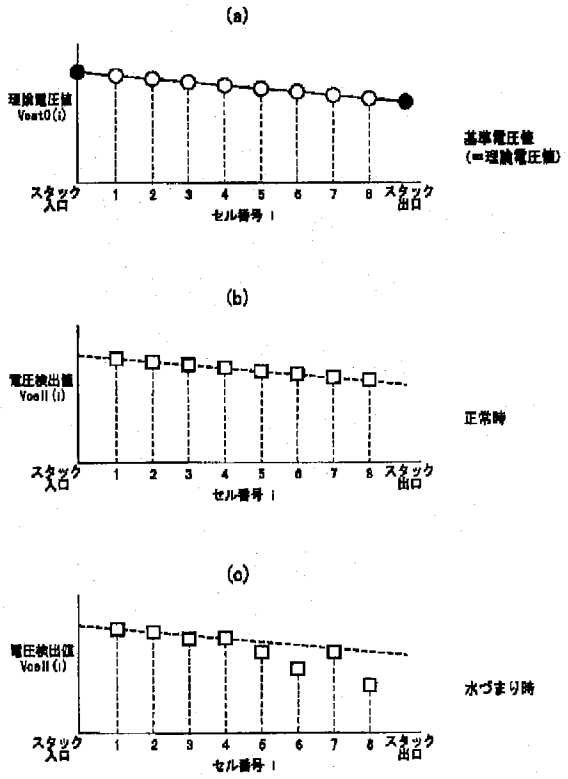
【図１４】



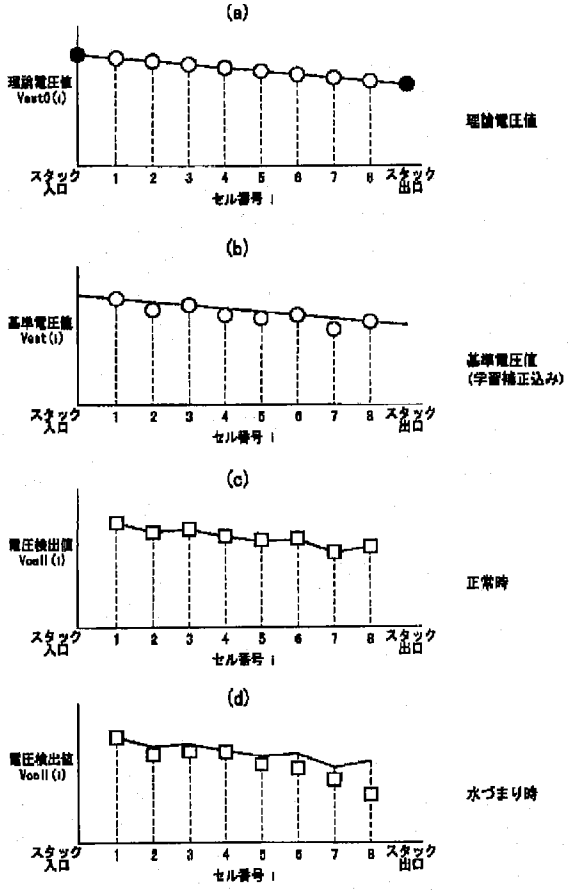
【図２】


210
コントローラ
207 純水ポンプ
211a
211b
211z
202
208
203 コンプレッサ
加湿器
201
空気
P
204 可変バルブ
205 スロットル
高圧水素
P
燃料電池スタック
209
206 パージ弁
電流

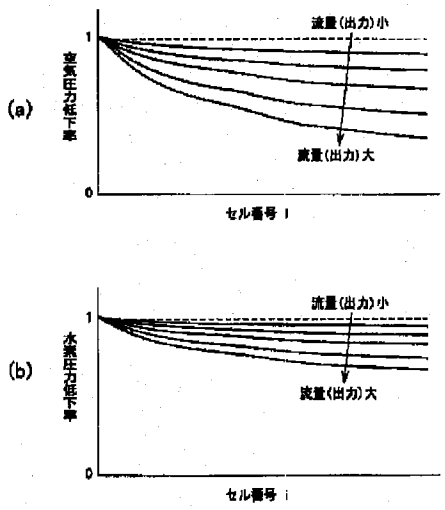
【図３】


(a)
理論電圧値
Vcat0 (i)
スタック入口
1 2 3 4 5 6 7 8
スタック出口
セル番号 i
基準電圧値
(=理論電圧値)
(b)
電圧検出値
Vcell (i)
正常時
(c)
水づまり時

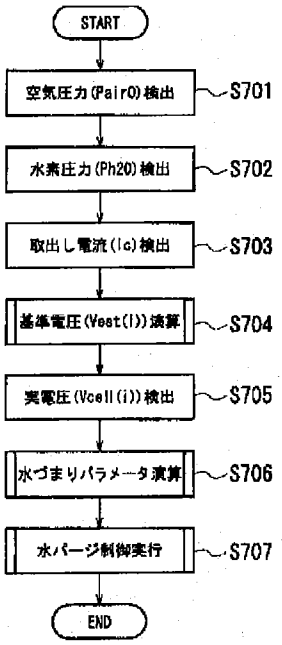
【図４】


(a)
理論電圧値
Vcat0 (i)
理論電圧値
(b)
基準電圧値
Vcat (i)
基準電圧値
(学習補正込み)
(c)
電圧検出値
Vcell (i)
正常時
(d)
水づまり時

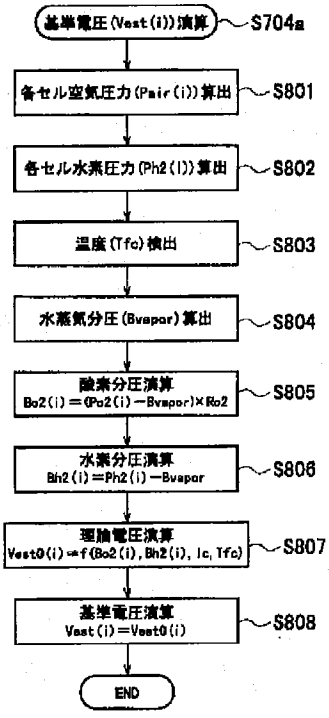
【図６】



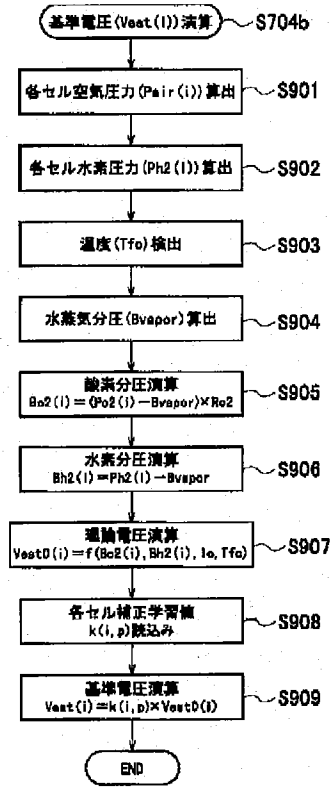
【図７】



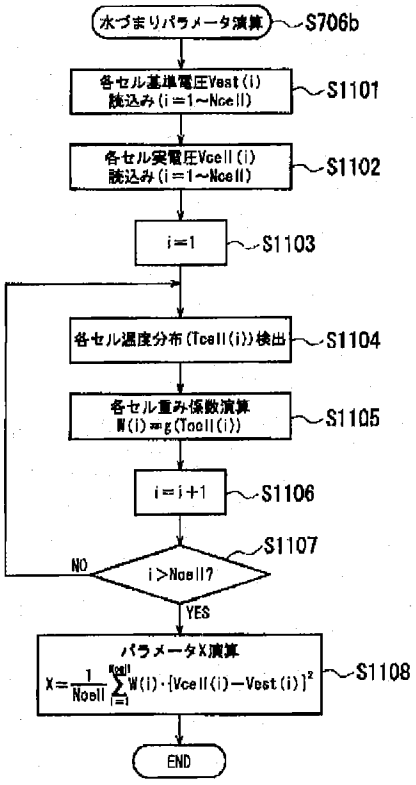
【図８】



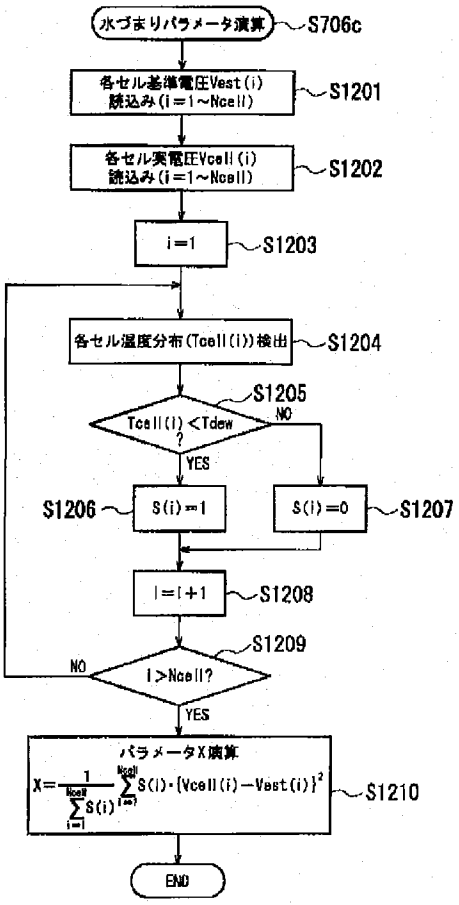
【図９】



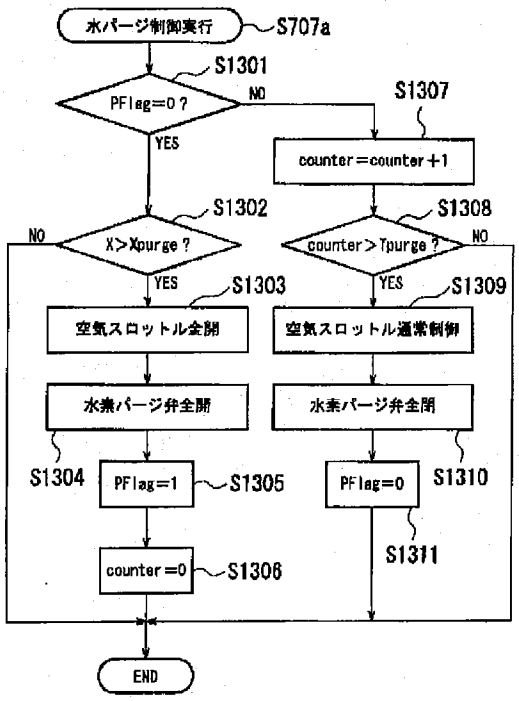
【図１１】



【図１２】


水づまりパラメータ演算
S706c
各セル基準電圧Vest(i)
読込み(i=1～Ncell)
S1201
各セル実電圧Vcell(i)
読込み(i=1～Ncell)
S1202
i=1
S1203
各セル温度分布(Tcell(i))検出
S1204
S1205
Tcell(i)<Tdew
?
NO
YES
S1206
S(i)=1
S(i)=0
S1207
i=i+1
S1208
S1209
i>Ncell?
NO
YES
パラメータX演算
S1210
END

【図１３】


水パージ制御実行
S707a
S1301
PFlag=0?
NO
YES
S1307
counter=counter+1
S1302
X>Xpurge?
NO
YES
S1308
counter>Tpurge?
NO
YES
S1303
空気スロットル全開
S1309
空気スロットル通常制御
水素パージ弁全開
水素パージ弁全閉
S1304
PFlag=1
S1305
PFlag=0
S1310
counter=0
S1306
S1311
END